

*Loren L. Bahls*

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ALGAE OF THE TONGUE RIVER SYSTEM  
MONTANA AND WYOMING

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Prepared for  
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Montana Department of Health & Environmental Sciences  
Billings

by  
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## INTRODUCTION

This report describes the diatom and nondiatom algae in 4 plankton and 13 periphyton samples from 12 sites on the Tongue River system, Montana and Wyoming. Samples were collected between September 8, 1975 and September 24, 1977. Seven of the sites are on the Tongue River mainstem (one in Wyoming and six in Montana), three are on Tongue River Reservoir, one is on Hanging Woman Creek, and one is at the Decker Mine discharge.

The samples are grouped according to their collection dates as follows:

### Group I. September 1975:

- ✓ 0100A; Decker Mine outfall; periphyton; 9-8-75
- ✓ 0115B; Tongue River @ Birney; <sup>Village</sup> periphyton; 9-28-75 (Tongue R. below Birney)
- ✓ 0116B; Tongue River @ Brandenburg; periphyton; 9-28-75
- ✓ 0119A; Tongue River @ Miles City; periphyton; 9-28-75

### Group II. October 1975:

- ✓ 0117A; Tongue River below Reservoir; periphyton; 10-21-75
- ✓ 0118A; Hanging Woman Creek @ Birney; periphyton; 10-21-75 (w/0426)
- no chem. ✓ 0115A; Tongue River @ Birney; <sup>Village</sup> periphyton; 10-30-75
- ✓ 0116A; Tongue River @ Brandenburg; periphyton; 10-30-75

### Group III. 1976:

- 11 ✓ 0218A; Tongue River Reservoir near shore; periphyton; 8-20-76
- ✓ 0227A; Tongue River Reservoir @ Midreservoir; plankton; 5-14-76
- 11 ✓ 0227B; Tongue River Reservoir @ Midreservoir; plankton; 5-29-76
- 11 ✓ 0227C; Tongue River Reservoir @ Station 2; plankton; undated
- 11 ✓ 0227D; Tongue River Reservoir @ Station 2; plankton; 10-16-76

### Group IV. September 1977:

- ✓ 0362A; Tongue River near Sheridan, Wyoming; periphyton; 9-24-77
- ✓ 0363A; Tongue River near Decker; periphyton; 9-24-77
- ✓ 0364A; Tongue River near Pyramid Butte; periphyton; 9-24-77
- ✓ 0116C; Tongue River @ Brandenburg; periphyton; 9-24-77

The identifying numbers in the left-hand column, e.g., 0227D and 0363A, are those that have been assigned to samples included in the permanent diatom slide collection of the Water Quality Bureau, Montana Department of Health and Environmental Sciences; for convenience, these numbers will be used to identify samples in the remainder of this report.

It should be noted here at the outset that all of the periphyton

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samples were collected within a three month time span, August through October. Even though the samples were collected in three different years, this seasonal consistency should allow some freedom in comparing periphyton communities longitudinally. However, because of the exclusively late summer and early autumn periphyton sampling, this report cannot address seasonal variation in community structure.

## METHODS

Periphyton samples were collected from natural substrates by Dr. Duane Klarich of the Water Quality Bureau, Montana Department of Health and Environmental Sciences, Billings. Plankton samples were collected by personnel from Montana State University and shipped to this investigator by Dr. Klarich.

The presence of nondiatom algae in each sample was determined by scanning a wet-mount subsample under 100X and 400X for approximately 20 minutes. Diatom percent relative abundance (PRA) was determined using a modification of the proportional count method prescribed by the Environmental Protection Agency (1973). (In excess of 300 cells, rather than the recommended 250 cells, were identified and tallied.)

Diatom diversity was calculated using Margalef's index (Hairston, 1959), Simpson's index (Simpson, 1949), and the Shannon-Weaver function (EPA, 1973). In addition, equitability (e) was calculated as advised by the Environmental Protection Agency (1973). Computational formulas for these indexes are presented in Table 2. Of these indexes, the Shannon-Weaver function and equitability are the most widely used and recommended. In unpolluted waters Shannon-Weaver diversity usually ranges between 3 and 4, whereas in polluted waters it is generally less than 1 (Wilhm, 1970). Equitability is thought to be even more sensitive to pollution; slight levels of pollution have been found to reduce equitability to below 0.5 and more severe degradation has reduced equitability to below 0.3 (EPA, 1973).

Two diatom taxa are especially useful as pollution indicators. The PRA of Achnanthes species is thought to be roughly proportional to the concentration of dissolved oxygen in water. On the other hand, the PRA of Nitzschia species often correlates directly with the degree of nitrogenous pollution (Cholnoky, 1968).

## RESULTS

Nondiatom algae found in the samples from the Tongue River system are listed in Table 1. Altogether, 36 genera were identified in seven major algal divisions. Most of the nondiatom genera (18) were green algae with the blue-green algae also contributing a significant number of genera (10). Tongue River Reservoir had six more nondiatom genera than the Tongue River mainstem, primarily on the strength of both periphyton and plankton collections in the reservoir as opposed to only periphyton collections from the river. (At least 10 of the nondiatom genera from the reservoir are considered strictly limnetic.) Hanging Woman Creek and the Decker Mine discharge each had a total of only three nondiatom genera. However, it should be kept in mind that these waters were represented by only one sample each, while the river was represented by 10 samples and the reservoir by 5 samples.

A total of 5,762 diatom cells was counted in the 17 samples, an average of 339 cells per sample. These individual cells were distributed among 173 distinct taxa and 33 genera. Forty-five percent of these 173 taxa were included in the genera Navicula (39 taxa) and Nitzschia (38 taxa). The PRA values of diatom taxa in each of the 17 samples are given in Appendixes A, B, C and D.

Table 2 lists values of selected diatom community parameters for each of the 17 samples. On the Tongue River itself, only two stations had diversity and equitability values showing some biological stress. These locations were immediately below the reservoir (117A) and at the river's mouth near Miles City (119A). Achnanthes spp. tended to be most plentiful along the middle river below the reservoir while Nitzschia spp. were consistently numerous throughout the length of the river with a slight depression in numbers immediately below the reservoir.

Diversity and equitability values for the Tongue River Reservoir probably should not be compared with those from the river or with literature values for stream communities because of the vastly different habitats involved: lenitic on the one hand and lotic on the other. The reservoir samples had consistently low numbers of Achnanthes spp., which is not surprising considering that this taxon has a sessile growth

Table 1. Nondiatom algal genera of the Tongue River system.

<u>GENUS</u>	<u>DIVISION</u>	<u>Tongue River Mainstem</u>	<u>Tongue River Reservoir</u>	<u>Hanging Woman Creek</u>	<u>Decker Mine Discharge</u>
Anabaena	BG	X	X		
Ankistrodesmus	G	X	X		
Aphanizomenon	BG		X		
Audouinella	R	X			
Chlorella	G		X		
Gladophora	G	X	X		
Glosteriopsis	G	X			
Glosterium	G	X			
Cosmarium	G	X	X		
Cryptomonas	U		X		
Dichothrix	BG	X			
Dinobryon	C		X		
Euglena	E		X		
Gloeocystis	G		X		
Lagynion	C		X		
Lyngbya	BG	X			
Merismopedia	BG		X		
Microcystis	BG		X		
Mougeotia	G	X	X		X
Oedogonium	G	X			
Oscillatoria	BG	X	X	X	
Pandorina	G		X		
Pediastrum	G	X	X		
Peridinium	P		X		
Phormidium	BG	X	X		X
Planktosphaeria	G	X			
Rhodomonas	U		X		
Rivularia	BG	X			
Scenedesmus	G	X	X		
Schroederia	G		X		
Spirogyra	G	X	X	X	
Stigeoclonium	G	X	X		X
Tolypothrix	BG		X		
Ulothrix	G	X			

Table 1. Continued.

<u>GENUS</u>	<u>DIVISION</u>	<u>Tongue River Mainstem</u>	<u>Tongue River Reservoir</u>	<u>Hanging Woman Creek</u>	<u>Decker Mine Discharge</u>
Vaucheria	C			X	
Zygnema	G		X		
Total Genera		20	26	3	3

EG = blue-green alga (Cyanophyta)

C = chrysophyte (Chrysophyta)

E = euglenoid (Euglenophyta)

G = green alga (Chlorophyta)

P = pyrrophyte (Pyrrophyta)

R = red alga (Rhodophyta)

U = an alga of uncertain systematic position

Table 2. Values for selected diatom community parameters, Tongue River system, Montana and Wyoming.

PARAMETER	TONGUE RIVER MAINSTEM									
	362A	363A	117A	364A	115A	115B	116A	116B	116C	119A
Total Taxa	48	50	32	55	68	62	61	64	45	55
Taxa Counted	38	42	18	33	41	37	44	36	33	33
Frustules Counted	325	345	355	320	346	327	332	319	358	324
Diversity										
Margalef (1)	6.40	7.02	2.90	5.55	6.84	6.22	7.41	6.07	5.44	5.54
Simpson (2)	.889	.927	.670	.897	.916	.866	.911	.866	.868	.703
Shannon-Weaver (3)	4.01	4.38	2.55	4.00	4.34	3.78	4.22	3.76	3.68	2.97
Equitability (4)	0.63	0.74	0.44	0.70	0.73	0.54	0.61	0.56	0.58	0.33
Percent Relative Abundance										
<i>Achnanthes</i> spp.	1.5	2.3	0.3	20.0	21.7	25.1	3.1	31.6	7.6	4.0
<i>Nitzschia</i> spp.	19.9	21.8	8.7	12.7	29.8	15.2	26.6	17.5	25.5	16.1

$$(1) (S - 1) / \log_e N \quad (\text{Hairston, 1959})$$

$$(2) 1 - \sum_{i=1}^s \left( \frac{n_i}{N} \right)^2 \quad (\text{Simpson, 1949})$$

$$(3) \frac{C}{N} (N \log_{10} N - \sum n_i \log_{10} n_i) \quad (\text{EPA, 1973})$$

$$(4) \frac{C}{S} \quad (\text{EPA, 1973})$$



Table 2. Continued.

PARAMETER	TONGUE RIVER RESERVOIR					HANGING WOMAN CREEK	DECKER MINE DICHARGE
	218A	227A	227B	227C	227D	118A	100A
Total Taxa	55	19	30	11	14	74	45
Taxa Counted	36	5	23	3	11	56	19
Frustules Counted	377	315	345	341	323	345	365
Diversity							
Margalef (1)	5.90	0.70	3.76	0.34	1.73	9.41	3.05
Simpson (2)	.745	.133	.713	.283	.556	.959	.676
Shannon-Weaver (3)	3.09	0.46	2.43	0.72	1.52	5.07	2.25
Equitability (4)	0.33	0.40	0.30	0.67	0.36	0.89	0.32
Percent Relative Abundance							
<i>Achnanthes</i> spp.	1.3	t	0.9	0	0.3	1.4	48.5
<i>Nitzschia</i> spp.	24.5	1.0	2.6	0	0.6	39.4	11.3

$$(1) (S - 1) / \log_e N \quad (\text{Hairston, 1959})$$

$$(2) 1 - \sum_{i=1}^S \left( \frac{n_i}{N} \right)^2 \quad (\text{Simpson, 1949})$$

$$(3) \frac{C}{N} (N \log_{10} N - \sum_{i=1}^S n_i \log_{10} n_i) \quad (\text{EPA, 1973})$$

$$(4) \frac{S'}{S} \quad (\text{EPA, 1973})$$

habit and is rarely found in the plankton. Nitzschia spp. was found in considerable numbers only in the one periphyton sample taken from the reservoir (0218A).

The single sample from Hanging Woman Creek (0118A) had the highest equitability and diversity values and the highest number of taxa of any sample analyzed in this study. Curiously, it also had the greatest relative abundance of Nitzschia spp. and one of the lowest relative abundances of Achnanthes spp.

The diatom community occupying the Decker Mine discharge on the date it was sampled indicated a moderate amount of stress in terms of its equitability and diversity values. However, the PRA of Achnanthes spp. was very high, implying that dissolved oxygen probably was not a problem.

## DISCUSSION

The algae identified from the Tongue River system generally indicate a moderately enriched, hardwater environment with tendencies toward eutrophication when impounded and excessive sediment and salinity near the lower end of the river.

The "stress" noted below the reservoir is probably thermal in nature. Diatom vulgare, which accounted for 55.5 percent of the diatoms at this location (0117A), is a winter dominant (Lowe, 1974) and probably responds favorably to the consistently cool water discharged from the dam. The drop in PRA Mitzschia spp. below the dam may reflect a depletion of biologically available nitrogen in the reservoir.

The stress documented at Miles City is probably of a different nature. The sample from this location (119A) was dominated by Amphipleura pellucida, which accounted for 52.8 percent of the diatoms. This taxon is free living, meaning that it can maintain its position on an aggrading, silt-covered bottom. It is also characteristic of eutrophic and hard or even slightly brackish water (Lowe, 1974; Patrick and Reimer, 1966).

The plankton flora of Tongue River Reservoir is relatively simple when compared to the periphyton floras of the reservoir and other waters in the Tongue River system. Of the blue-green algae found in the reservoir plankton, two genera--Aphanizomenon and Microcystis--are capable of producing intensive and potentially toxic blooms.

Hanging Woman Creek had exceptional diatom diversity; no single taxon accounted for more than 10 percent of the total number of cells counted. Even so, the diatom flora of this stream indicated higher nutrient and salinity values than for stations on the mainstem of the Tongue River.

The Decker Mine discharge sample was dominated by Achnanthes minutissima (48.5 %) and Cymbella affinis (28.2 %). These taxa probably indicate a hardwater discharge with a relatively warm temperature, yet with more than adequate dissolved oxygen. There is no evidence of any toxic materials in this discharge.

#### LITERATURE CITED

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APPENDIX A. Percent relative abundance of diatom taxa from the Decker mine outfall and the Tongue River, September 1975.

	0100A	0115B	0116B	0119A
<i>Achnanthes affinis</i> Grun.				
<i>A. clevei</i> Grun.				
<i>A. clevei</i> var. <i>rostrata</i> Hust.		0.3	0.3	
<i>A. lanceolata</i> (Breb.) Grun.			t	
<i>A. lanceolata</i> var. <i>dubia</i> Grun.	t	t	0.3	
<i>A. linearis</i> (W. Sm.) Grun.	t		t	
<i>A. minutissima</i> Kutz.	48.5	24.8	31.0	4.0
<i>Amphipleura pellucida</i> Kutz.				52.8
<i>Amphora ovalis</i> var. <i>affinis</i> (Kutz.) V.H. ex DeT.		t		
<i>A. ovalis</i> var. <i>pediculus</i> (Kutz.) V.H.		0.6	1.2	0.3
<i>A. perpusilla</i> (Grun.) Grun.				
<i>A. veneta</i> (Kutz.) Hust.				
<i>Anomoeoneis vitrea</i> (Grun.) Ross comb. nov.	0.6			
<i>Asterionella formosa</i> Hass.			0.3	
<i>Bacillaria paradoxa</i> Gmel.				
<i>Caloneis amphisbaena</i> (Bory) Cl.		t	t	t
<i>C. bacillum</i> (Grun.) Cl.			t	t
<i>C. hyalina</i> Hust.				
<i>C. lewisii</i> Patr.			t	
<i>C. limosa</i> (Kutz.) Patr. comb. nov.				
<i>C. ventricosa</i> var. <i>truncatula</i> (Grun.) Meist.			t	
<i>C. sp.</i>		0.3		
<i>Cocconeis pediculus</i> Ehr.		23.8	11.9	0.3
<i>C. placentula</i> Ehr.		3.7		0.3
<i>C. placentula</i> var. <i>euglypta</i> (Ehr.) Cl.		5.8	2.5	0.3
<i>Cyclotella meneghiniana</i> Kutz.		1.5	0.6	0.9
<i>C. sp.</i>				
<i>Cymatopleura elliptica</i> var. <i>nobilis</i> (Hant.) Hust.				
<i>C. solea</i> (Breb. & Godey) W. Sm.		t	t	t
<i>Cymbella affinis</i> Kutz.	28.2	0.9	0.3	0.3
<i>C. cistula</i> (Ehr.) Kirchn.	t			t
<i>C. cymbiformis</i> Ag.	0.3			
<i>C. mexicana</i> (Ehr.) Cleve		t		
<i>C. microcephala</i> Grun.	1.1		t	0.3
<i>C. minuta</i> Hilse ex Rabh.	t	0.6	t	
<i>C. muelleri</i> Hust.				

## APPENDIX A. Continued

	<u>0100A</u>	<u>0155B</u>	<u>0116B</u>	<u>0119A</u>
<i>Cymbella prostrata</i> (Berkeley) Cl.		t		
<i>C. prostrata</i> var. <i>auerswaldii</i> (Rabh.) Reim. comb. nov.				
<i>C. pusilla</i> Grun.	0.3			
<i>C. sinuata</i> Greg.		0.6	0.9	0.3
<i>C. tumida</i> (Breb.) V.H.				
<i>Denticula</i> sp.				
<i>Diatoma elongatum</i> var. <i>minor</i> Grun.				
<i>D. tenue</i> var. <i>elongatum</i> Lyngb.	t			
<i>D. vulgare</i> Bory		2.8	2.2	0.9
<i>Diploneis puella</i> (Schum.) Cl.				t
<i>Entomoneis alata</i> (Ehr.) Ehr.				
<i>E. paludosa</i> (W. Sm.) Reim. comb. nov.	t			
<i>Epithemia adnata</i> (Kutz.) Breb.				
<i>E. adnata</i> var. <i>proboscidea</i> (Kutz.) Patr. comb. nov.				
<i>E. adnata</i> var. <i>saxonica</i> (Kutz.) Patr. comb. nov.				
<i>E. sorex</i> Kutz.		t		
<i>E. sp.</i>			t	
<i>Fragilaria brevistriata</i> var. <i>inflata</i> (Pant.) Hust.				
<i>F. construens</i> var. <i>venter</i> (Ehr.) Grun.		0.3		
<i>F. crotonensis</i> Kitton.		t		0.3
<i>F. vaucheriae</i> (Kutz.) Peters	1.9	0.9	0.3	
<i>F. virescens</i> var. <i>capitata</i> Østr.				
<i>Frustulia weinholdii</i> Hust.				
<i>Gomphoneis herculeana</i> var. <i>robusta</i> (Grun.) Cl.				
<i>Gomphonema acuminatum</i> Ehr.				
<i>G. affine</i> Kutz.	t			
<i>G. angustatum</i> (Kutz.) Rabh.	0.3			
<i>G. angustatum</i> var. <i>sarcophagus</i> (Greg.) Grun.				
<i>G. dichotomum</i> Kutz.				0.6
<i>G. intricatum</i> Kutz.	0.3			t
<i>G. olivaceum</i> (Lyngb.) Kutz.	t	1.5	t	0.3
<i>G. olivaceum</i> var. <i>calcareum</i> (Cl.) Cl.				
<i>G. parvulum</i> Kutz.				
<i>G. subclavatum</i> (Grun.) Grun.				
<i>G. sp.</i>		4.0	7.8	0.9

## APPENDIX A. Continued

	0100A	0115B	0116B	0119A
<i>Gyrosigma spencerii</i> (Quek.) Griff. & Henfr.	0.6	0.3	0.3	
<i>Hantzschia amphioxys</i> (Ehr.) Grun.			0.3	
<i>H. amphioxys</i> fo. <i>capitata</i> Hust.	t.			
<i>Mastogloia smithii</i> Thwaites ex W. Sm.				
<i>M. smithii</i> var. <i>lacustris</i> Grun.				
<i>Melosira granulata</i> (Ehr.) Ralfs.				
<i>M. granulata</i> var. <i>angustissima</i> Mull.		t	t	1.2
<i>M. varians</i> Ag.		t	0.6	
<i>Navicula anglica</i> Ralfs.				
<i>N. anglica</i> var. <i>subsalsa</i> (Grun.) Cl.		t	t	
<i>N. capitata</i> Ehr.		0.3		
<i>N. capitata</i> var. <i>hungarica</i> (Grun.) Ross				
<i>N. cincta</i> (Ehr.) Ralfs.				
<i>N. cincta</i> var. <i>rostrata</i> Reim.				
<i>N. circumtexta</i> Meist. ex Hust.				
<i>N. cryptocephala</i> Kutz.	4.4	1.5	6.6	5.6
<i>N. cryptocephala</i> var. <i>veneta</i> (Kutz.) Rabh.	t	2.4	3.1	1.5
<i>N. cuspidata</i> (Kutz.) Kutz.	t		t	t
<i>N. decussis</i> Østr.				
<i>N. elmorei</i> Patr.				
<i>N. exigua</i> var. <i>capitata</i> Patr.				
<i>N. hambergii</i> Hust.			t	t
<i>N. heufleri</i> Grun.				
<i>N. heufleri</i> var. <i>leptocephala</i> (Breb. & Grun.) Patr.				1.2
<i>N. lanceolata</i> (Ag.) Kutz.				
<i>N. minima</i> Grun.				
<i>N. minuscula</i> Grun.			0.9	
<i>N. mournei</i> Patr.				
<i>N. notha</i> Wallace	t			t
<i>N. pelliculosa</i> (Breb. ex Kutz.) Hilse				
<i>N. peregrina</i> (Ehr.) Kutz.			t	
<i>N. protracta</i> Grun.				
<i>N. pupula</i> Kutz.		t		
<i>N. pupula</i> var. <i>capitata</i> Skv. & Meyer		t	0.3	t
<i>N. pygmaea</i> Kutz.			t	
<i>N. radiosa</i> var. <i>parva</i> Wallace		0.3		

## APPENDIX A. Continued

	0100A	0115B	0116B	0119A
<i>Navicula radiosa</i> var. <i>tenella</i> (Breb. & Kutz.) Grun.				
<i>N. rhynchocephala</i> Kutz.	t		t	
<i>N. rhynchocephala</i> var. <i>germanii</i> (Wallace) Patr. comb. nov.				
<i>N. secreta</i> var. <i>apiculata</i> Patr.				
<i>N. symmetrica</i> Patr.			0.3	t
<i>N. tenelloides</i> Hust.				
<i>N. tripunctata</i> (O. F. Mull.) Bory	0.3	1.2	1.2	0.6
<i>N. viridula</i> (Kutz.) Kutz.	t			
<i>N. viridula</i> var. <i>avenacea</i> (Breb. & Grun.) V.H.				
<i>N. viridula</i> var. <i>rostellata</i> (Kutz.) Cl.		0.3	t	t
<i>N. sp.</i>	t			
<i>Neidium dubium</i> (Ehr.) Cl.		t		
<i>N. iridis</i> var. <i>ampliatum</i> (Ehr.) Cl.				
<i>N. sp.</i>				
<i>Nitzschia acicularis</i> (Kutz.) W. Sm.		1.5	3.1	1.8
<i>N. acuminata</i> (W. Sm.) Grun.				
<i>N. amphibia</i> Grun.				
<i>N. angustata</i> (W. Sm.) Grun.		t		
<i>N. angustata</i> var. <i>acuta</i> Grun.				t
<i>N. apiculata</i> (Greg.) Grun...	t	0.3	t	t
<i>N. bulnheimiana</i> (Rabh.) H. L. Sm.	7.7			
<i>N. capitellata</i> Hust.	t			
<i>N. clausii</i> Hantz.	t			1.8
<i>N. communis</i> Rabh.	t		t	
<i>N. denticula</i> Grun.	2.2			
<i>N. dissipata</i> (Kutz.) Grun.		6.1	5.3	4.3
<i>N. epiphytica</i> O. Mull.			t	t
<i>N. filiformis</i> (W. Sm.) Hust.				t
<i>N. fonticola</i> Grun.				
<i>N. frustulum</i> Kutz.		t	0.3	0.3
<i>N. frustulum</i> var. <i>subsalina</i> Hust.		0.3	2.2	0.9
<i>N. gracilis</i> Hantz.			2.2	1.5
<i>N. holsatica</i> Hust.				
<i>N. hungarica</i> Grun.		t	t	
<i>N. kutzlingiana</i> Hilse				
<i>N. linearis</i> (Ag. ex W. Sm.) W. Sm.		t	0.3	0.9



## APPENDIX A. Continued

	<u>0100A</u>	<u>0115B</u>	<u>0116B</u>	<u>0119A</u>
<i>Nitzschia longissima</i> var. <i>reversa</i> Grun.				
<i>N. microcephala</i> Grun.		0.3		
<i>N. palea</i> (Kutz.) W. Sm.	1.4	4.9	4.1	4.6
<i>N. paleacea</i> Grun.				
<i>N. recta</i> Hantz.		0.3		t
<i>N. romana</i> Grun.	t			
<i>N. sigma</i> (Kutz.) W. Sm.	t			
<i>N. sigmoidea</i> (Ehr.) W. Sm.		0.3	t	
<i>N. sublinearis</i> Hust.		1.2		
<i>N. tryblionella</i> Hantz.				
<i>N. tryblionella</i> var. <i>debilis</i> (Arnott) A. Mayer				
<i>N. tryblionella</i> var. <i>levidensis</i> (W. Sm.) Grun.				
<i>N. tryblionella</i> var. <i>victoriae</i> Grun.				
<i>N. valdestriata</i> Aleem & Hust.				
<i>N. vermicularis</i> (Kutz.) Hant.	t	t	t	t
<i>N. sp.</i>				
<i>Pinnularia borealis</i> Ehr.				
<i>P. kneuckerii</i> Hust.				
<i>P. sp.</i>				
<i>Pleurosigma delicatulum</i> W. Sm.	0.6	t	0.3	t
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.		1.8	0.6	
<i>Rhopalodia gibba</i> (Ehr.) O. Mull.		t		t
<i>R. gibba</i> var. <i>ventricosa</i> (Kutz.) H. & M. Perag.				
<i>R. musculus</i> (Kutz.) O. Mull.			t	
<i>Stauroneis</i> sp. Ehr.				
<i>Stephanodiscus astraea</i> (Ehr.) Grun.		0.9	0.3	
<i>S. minutus</i> Cl. & Moll.		1.8	6.6	8.6
<i>S. niagarae</i> Ehr.		0.9	0.3	0.6
<i>Surirella angustata</i> Kutz.			0.3	0.6
<i>S. iowensis</i> Lowe				t
<i>S. ovalis</i> Breb.				
<i>S. ovata</i> Kutz.	t	t		
<i>S. tenera</i> Greg.		t		t
<i>Synedra acus</i> Kutz.		t		
<i>S. cyclopus</i> Brutschy				

APPENDIX A. Concluded

	<u>0100A</u>	<u>0115B</u>	<u>0116B</u>	<u>0119A</u>
<i>Synedra delicatissima</i> W. Sm.	t	t		
<i>S. fasciculata</i> var. <i>truncata</i> (Grev.) Patr.	t			
<i>S. goulardi</i> Breb.				
<i>S. mazamaensis</i> Sov.				
<i>S. radians</i> Kutz.	0.6			
<i>S. rumpens</i> Kutz.	0.3			
<i>S. ulna</i> (Nitz. ) Ehr.	t	0.3	0.3	0.3
<i>S. ulna</i> var. <i>contracta</i> Østr.			t	
<i>S. ulna</i> var. <i>spathulifera</i> (Grun.) V.H.				
<i>S. sp.</i>				

APPENDIX B. Percent relative abundance of diatom taxa from Hanging Woman Creek and the Tongue River, October 1975.

	<u>0117A</u>	<u>0118A</u>	<u>0115A</u>	<u>0116A</u>
<i>Achnanthes affinis</i> Grun.				
<i>A. clevei</i> Grun.				
<i>A. clevei</i> var. <i>rostrata</i> Hust.			t	
<i>A. lanceolata</i> (Breb.) Grun.				
<i>A. lanceolata</i> var. <i>dubia</i> Grun.			t	
<i>A. linearis</i> (W. Sm.) Grun.				0.3
<i>A. minutissima</i> Kutz.	0.3	1.4	21.7	21.8
<i>Amphipleura pellucida</i> Kutz.		4.1		
<i>Amphora ovalis</i> var. <i>affinis</i> (Kutz.) V.H. ex Det.		0.3		
<i>A. ovalis</i> var. <i>pediculus</i> (Kutz.) V.H.		0.9	0.6	t
<i>A. perpusilla</i> (Grun.) Grun.				
<i>A. veneta</i> (Kutz.) Hust.		t		
<i>Anomoeoneis vitrea</i> (Grun.) Ross comb. nov.				
<i>Asterionella formosa</i> Hass.	t		t	0.3
<i>Bacillaria paradoxa</i> Gmel.		0.6		
<i>Caloneis amphisbaena</i> (Bory) Cl.		0.3	0.3	t
<i>C. bacillum</i> (Grun.) Cl.		0.3		
<i>C. hyalina</i> Hust.				0.3
<i>C. lewisii</i> Patr.				
<i>C. limosa</i> (Kutz.) Patr. comb. nov.		t		
<i>C. ventricosa</i> var. <i>truncatula</i> (Grun.) Meist.				
<i>C. sp.</i>				
<i>Cocconeis pediculus</i> Ehr.	1.4		4.6	3.3
<i>C. placentula</i> Ehr.		0.9		
<i>C. placentula</i> var. <i>euglypta</i> (Ehr.) Cl.			1.7	3.6
<i>Cyclotella meneghiniana</i> Kutz.		2.6	0.3	0.6
<i>C. sp.</i>				
<i>Cymatopleura elliptica</i> var. <i>nobilis</i> (Hant.) Hust.				
<i>C. solea</i> (Breb. & Godey) W. Sm.			0.9	t
<i>Cymbella affinis</i> Kutz.	8.4	2.0	t	0.3
<i>C. cistula</i> (Ehr.) Kirchn.				
<i>C. cymbiformis</i> Ag.		t		
<i>C. mexicana</i> (Ehr.) Cleve		t	0.3	
<i>C. microcephala</i> Grun.				
<i>C. minuta</i> Hilse ex Rabh.		1.2	0.9	0.3
<i>C. muelleri</i> Hust.		0.3		

## APPENDIX B. Continued

	0117A	0118A	0115A	0116A
<i>Cymbella prostrata</i> (Berkeley) Cl.				
<i>C. prostrata</i> var. <i>auerswaldii</i> (Rabh.) Reim. comb. nov.				
<i>C. pusilla</i> Grun.				
<i>C. sinuata</i> Greg.			t	1.5
<i>C. tumida</i> (Breb.) V.H.	t			t
<i>Denticula</i> sp.				
<i>Diatoma elongatum</i> var. <i>minor</i> Grun.		t		
<i>D. tenue</i> var. <i>elongatum</i> Lyngb.		0.3		
<i>D. vulgare</i> Bory	55.5		3.2	0.9
<i>Diploneis puella</i> (Schum.) Cl.		3.5		
<i>Entomoneis alata</i> (Ehr.) Ehr.		t		
<i>E. paludosa</i> (W. Sm.) Reim. comb. nov.		1.2		
<i>Epithemia adnata</i> (Kutz.) Breb.				0.3
<i>E. adnata</i> var. <i>proboscidea</i> (Kutz.) Patr. comb. nov.				
<i>E. adnata</i> var. <i>saxonica</i> (Kutz.) Patr. comb. nov.				
<i>E. sorex</i> Kutz.			t	
<i>E. sp.</i>				
<i>Fragilaria brevistriata</i> var. <i>inflata</i> (Pant.) Hust.		0.3		0.2
<i>F. construens</i> var. <i>venter</i> (Ehr.) Grun.				
<i>F. crotonensis</i> Kitton.	4.5		0.6	t
<i>F. vaucheriae</i> (Kutz.) Peters	2.0	0.6	1.4	3.6
<i>F. virescens</i> var. <i>capitata</i> Østr.		0.6		
<i>Frustulia weinholdii</i> Hust.				0.3
<i>Gomphoneis herculeana</i> var. <i>robusta</i> (Grun.) Cl.	t		t	
<i>Gomphonema acuminatum</i> Ehr.				
<i>G. affine</i> Kutz.				
<i>G. angustatum</i> (Kutz.) Rabh.				
<i>G. angustatum</i> var. <i>sarcophagus</i> (Greg.) Grun.				
<i>G. dichotomum</i> Kutz.				
<i>G. intricatum</i> Kutz.				
<i>G. olivaceum</i> (Lyngb.) Kutz.	7.0	0.3	6.1	2.7
<i>G. olivaceum</i> var. <i>calcareum</i> (Cl.) Cl.	t	t		t
<i>G. parvulum</i> Kutz.				
<i>G. subclavatum</i> (Grun.) Grun.				
<i>G. sp.</i>	t		3.2	5.8

## APPENDIX B. Continued

	0117A	0118A	0115A	0116A
<i>Gyrosigma spencerii</i> (Quek.) Griff. & Henfr.		0.3	0.3	0.3
<i>Hantzschia amphioxys</i> (Ehr.) Grun.			t	
<i>H. amphioxys</i> fo. <i>capitata</i> Hust.				
<i>Mastogloia smithii</i> Thwaites ex W. Sm.		0.6		
<i>M. smithii</i> var. <i>lacustris</i> Grun.		0.6		
<i>Melosira granulata</i> (Ehr.) Ralfs.				
<i>M. granulata</i> var. <i>angustissima</i> Mull.				
<i>M. varians</i> Ag.	1.4	t	1.7	t
<i>Navicula anglica</i> Ralfs.				
<i>N. anglica</i> var. <i>subsalsa</i> (Grun.) Gl.			t	0.3
<i>N. capitata</i> Ehr.			0.3	t
<i>N. capitata</i> var. <i>hungarica</i> (Grun.) Ross		t		
<i>N. cincta</i> (Ehr.) Ralfs.				
<i>N. cincta</i> var. <i>rostrata</i> Reim.				
<i>N. circumtexta</i> Meist. ex Hust.		2.0		t
<i>N. cryptocephala</i> Kutz.	0.8		1.2	6.1
<i>N. cryptocephala</i> var. <i>veneta</i> (Kutz.) Rabh.	1.1	5.2	8.1	5.8
<i>N. cuspidata</i> (Kutz.) Kutz.			t	
<i>N. decussis</i> Østr.				
<i>N. elmorei</i> Patr.				
<i>N. exigua</i> var. <i>capitata</i> Patr.				
<i>N. hambergii</i> Hust.				
<i>N. heufleri</i> Grun.				
<i>N. heufleri</i> var. <i>leptocephala</i> (Breb. & Grun.) Patr.				
<i>N. lanceolata</i> (Ag.) Kutz.	t			
<i>N. minima</i> Grun.				
<i>N. minuscula</i> Grun.			0.9	3.3
<i>N. mournei</i> Patr.				
<i>N. notha</i> Wallace				0.6
<i>N. pelliculosa</i> (Breb. ex Kutz.) Hilse				0.3
<i>N. peregrina</i> (Ehr.) Kutz.		0.6		
<i>N. protracta</i> Grun.				
<i>N. pupula</i> Kutz.				
<i>N. pupula</i> var. <i>capitata</i> Skv. & Meyer			t	t
<i>N. pygmaea</i> Kutz.				
<i>N. radiosa</i> var. <i>parva</i> Wallace				0.6

## APPENDIX B. Continued

	0117A	0118A	0115A	0116A
<i>Navicula radiosa</i> var. <i>tenella</i> (Breb. & Kutz.) Grun.	t			
<i>N. rhynchocephala</i> Kutz.		2.0	0.9	1.2
<i>N. rhynchocephala</i> var. <i>germanii</i> (Wallace) Patr. comb. nov.				
<i>N. secreta</i> var. <i>apiculata</i> Patr.				
<i>N. symmetrica</i> Patr.				0.3
<i>N. tenelloides</i> Hust.				
<i>N. tripunctata</i> (O. F. Mull.) Bory	t	2.6	2.3	0.6
<i>N. viridula</i> (Kutz.) Kutz.				t
<i>N. viridula</i> var. <i>avenacea</i> (Breb. & Grun.) V.H.		0.3	t	0.6
<i>N. viridula</i> var. <i>rostellata</i> (Kutz.) Cl.			t	
<i>N. sp.</i>	t	0.9		0.3
<i>Neidium dubium</i> (Ehr.) Cl.			t	
<i>N. iridis</i> var. <i>ampliatum</i> (Ehr.) Cl.			t	
<i>N. sp.</i>		7.2	0.3	1.3
<i>Nitzschia acicularis</i> (Kutz.) W. Sm.		7.2	0.9	1.2
<i>N. acuminata</i> (W. Sm.) Grun.		9.3		
<i>N. amphibia</i> Grun.				
<i>N. angustata</i> (W. Sm.) Grun.		t		t
<i>N. angustata</i> var. <i>acuta</i> Grun.		0.3		
<i>N. apiculata</i> (Greg.) Grun...		2.0	0.6	0.3
<i>N. bulnheimiana</i> (Rabh.) H. L. Sm.				
<i>N. capitellata</i> Hust.		t	t	
<i>N. clausii</i> Hantz.				
<i>N. communis</i> Rabh.		2.3	0.6	
<i>N. denticula</i> Grun.				
<i>N. dissipata</i> (Kutz.) Grun.	3.9	2.0	10.7	9.4
<i>N. epiphytica</i> O. Mull.			t	t
<i>N. filiformis</i> (W. Sm.) Hust.		5.8	t	
<i>N. fonticola</i> Grun.			t	
<i>N. frustulum</i> Kutz.	0.6	7.8	0.6	0.9
<i>N. frustulum</i> var. <i>subsalina</i> Hust.		2.0		0.6
<i>N. gracilis</i> Hantz.			2.0	1.5
<i>N. holsatica</i> Hust.				
<i>N. hungarica</i> Grun.			t	
<i>N. kutzingiana</i> Hilse				
<i>N. linearis</i> (Ag. ex W. Sm.) W. Sm.		0.9	1.2	0.6

## APPENDIX B. Continued

	<u>0117A</u>	<u>0118A</u>	<u>0115A</u>	<u>0116A</u>
<i>Nitzschia longissima</i> var. <i>reversa</i> Grun.				
<i>N. microcephala</i> Grun.				
<i>N. palea</i> (Kutz.) W. Sm.	4.2	4.4	6.9	10.9
<i>N. paleacea</i> Grun.	t	2.3	1.4	
<i>N. recta</i> Hantz.	t		4.3	
<i>N. romana</i> Grun.			0.3	0.3
<i>N. sigma</i> (Kutz.) W. Sm.		0.9		0.6
<i>N. sigmoidea</i> (Ehr.) W. Sm.		t	t	t
<i>N. sublinearis</i> Hust.				
<i>N. tryblionella</i> Hantz.				t
<i>N. tryblionella</i> var. <i>debilis</i> (Arnott) A. Mayer		0.9		
<i>N. tryblionella</i> var. <i>levidensis</i> (W. Sm.) Grun.		t	0.3	
<i>N. tryblionella</i> var. <i>victoriae</i> Grun.		t		
<i>N. valdestriata</i> Aleem & Hust.		0.3		
<i>N. vermicularis</i> (Kutz.) Hant.			t	0.3
<i>N. sp.</i>		0.8		
<i>Pinnularia borealis</i> Ehr.				
<i>P. kneuckerii</i> Hust.		t		
<i>P. sp.</i>				
<i>Pleurosigma delicatulum</i> W. Sm.		4.1	t	0.9
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.	0.8	0.6	1.2	
<i>Rhopalodia gibba</i> (Ehr.) O. Mull.		2.0		
<i>R. gibba</i> var. <i>ventricosa</i> (Kutz.) H. & M. Perag.				
<i>R. musculus</i> (Kutz.) O. Mull.		0.6		
<i>Stauroneis</i> sp. Ehr.		0.3		
<i>Stephanodiscus astraea</i> (Ehr.) Grun.	5.6	0.6	0.9	0.3
<i>S. minutus</i> Cl. & Moll.	0.6	9.6	1.4	5.4
<i>S. niagarae</i> Ehr.	0.6		2.3	t
<i>Surirella angustata</i> Kutz.			t	
<i>S. iowensis</i> Lowe				
<i>S. ovalis</i> Breb.		0.3		
<i>S. ovata</i> Kutz.		3.8	t	
<i>S. tenera</i> Greg.			t	
<i>Synedra acus</i> Kutz.				
<i>S. cyclopus</i> Brutschy				

## APPENDIX B. Concluded

	<u>0117A</u>	<u>0118A</u>	<u>0115A</u>	<u>0116A</u>
<i>Synedra delicatissima</i> W. Sm.			0.6	
<i>S. fasciculata</i> var. <i>truncata</i> (Grev.) Patr.				t
<i>S. goulardi</i> Breb.				t
<i>S. mazamaensis</i> Sov.				t
<i>S. radians</i> Kutz.	t	1.4		
<i>S. rumpens</i> Kutz.				
<i>S. ulna</i> (Nitz. ) Ehr.	1.1	0.6		t
<i>S. ulna</i> var. <i>contracta</i> Østr.	t	0.3	2.0	
<i>S. ulna</i> var. <i>spathulifera</i> (Grun.) V.H.				
<i>S. sp.</i>			t	



APPENDIX C. Percent relative abundance of diatom taxa in periphyton (0218) and plankton (0227) samples from Tongue River Reservoir, 1976.

0227A 0227B 0227C 0227D 0218A

*Achnanthes affinis* Grun.

*A. clevei* Grun.

*A. clevei* var. *rostrata* Hust.

*A. lanceolata* (Breb.) Grun.

0.3 0.3

*A. lanceolata* var. *dubia* Grun.

*A. linearis* (W. Sm.) Grun.

*A. minutissima* Kutz.

t 0.6 1.3

*Amphipleura pellucida* Kutz.

*Amphora ovalis* var. *affinis* (Kutz.) V.H. ex Def.

t

*A. ovalis* var. *pediculus* (Kutz.) V.H.

0.3 0.3 t

*A. perpusilla* (Grun.) Grun.

*A. veneta* (Kutz.) Hust.

0.3 t

*Anomoeoneis vitrea* (Grun.) Ross comb. nov.

*Asterionella formosa* Hass.

t 8.7 15.2 5.9 0.3

*Bacillaria paradoxa* Gmel.

*Caloneis amphibaena* (Bory) Cl.

*C. bacillum* (Grun.) Cl.

*C. hyalina* Hust.

*C. lewisii* Patr.

*C. limosa* (Kutz.) Patr. comb. nov.

*C. ventricosa* var. *truncatula* (Grun.) Meist.

*C. sp.*

*Cocconeis pediculus* Ehr.

*C. placentula* Ehr.

0.6

*C. placentula* var. *euglypta* (Ehr.) Cl.

*Cyclotella meneghiniana* Kutz.

0.6 t t 0.8

*C. sp.*

0.3 t

*Cymatopleura elliptica* var. *nobilis* (Hant.) Hust.

*C. solea* (Breb. & Godey) W. Sm.

*Cymbella affinis* Kutz.

0.3

*C. cistula* (Ehr.) Kirchn.

*C. cymbiformis* Ag.

*C. mexicana* (Ehr.) Cleve

*C. microcephala* Grun.

*C. minuta* Hilse ex Rabh.

1.1

*C. muelleri* Hust.

## APPENDIX C. Continued

	0227A	0227B	0227C	0227D	0218A
<i>Cymbella prostrata</i> (Berkeley) Cl.					
<i>C. prostrata</i> var. <i>auerswaldii</i> (Rabh.) Reim. comb. nov.					
<i>C. pusilla</i> Grun.					
<i>C. sinuata</i> Greg.					
<i>C. tumida</i> (Breb.) V.H.					0.3
<i>Denticula</i> sp.	t				t
<i>Diatoma elongatum</i> var. <i>minor</i> Grun.					
<i>D. tenue</i> var. <i>elongatum</i> Lyngb.				t	
<i>D. vulgare</i> Bory	t	0.9			
<i>Diploneis puella</i> (Schum.) Cl.					
<i>Entomoneis alata</i> (Ehr.) Ehr.					
<i>E. paludosa</i> (W. Sm.) Reim. comb. nov.					
<i>Epithemia adnata</i> (Kutz.) Breb.					
<i>E. adnata</i> var. <i>proboscidea</i> (Kutz.) Patr. comb. nov.					
<i>E. adnata</i> var. <i>saxonica</i> (Kutz.) Patr. comb. nov.					
<i>E. sores</i> Kutz.					0.3
<i>E. sp.</i>					
<i>Fragilaria brevistriata</i> var. <i>inflata</i> (Pant.) Hust.					
<i>F. construens</i> var. <i>venter</i> (Ehr.) Grun.		t			
<i>F. crotonensis</i> Kitton.	t	3.5	83.3	58.5	47.5
<i>F. vaucheriae</i> (Kutz.) Peters					0.3
<i>F. virescens</i> var. <i>capitata</i> Østr.					
<i>Frustulia weinholdii</i> Hust.					
<i>Gomphoneis herculeana</i> var. <i>robusta</i> (Grun.) Cl.					
<i>Gomphonema acuminatum</i> Ehr.					t
<i>G. affine</i> Kutz.					
<i>G. angustatum</i> (Kutz.) Rabh.					
<i>G. angustatum</i> var. <i>sarcophagus</i> (Greg.) Grun.					t
<i>G. dichotomum</i> Kutz.					t
<i>G. intricatum</i> Kutz.					
<i>G. olivaceum</i> (Lyngb.) Kutz.		t			
<i>G. olivaceum</i> var. <i>calcareum</i> (Cl.) Cl.					
<i>G. parvulum</i> Kutz.					t
<i>G. subclavatum</i> (Grun.) Grun.					
<i>G. sp.</i>					

## APPENDIX C. Continued

	<u>0227A</u>	<u>0227B</u>	<u>0227C</u>	<u>0227D</u>	<u>0218A</u>
<i>Gyrosigma spencerii</i> (Quek.) Griff. & Henfr.					
<i>Hantzschia amphioxys</i> (Ehr.) Grun.					
<i>H. amphioxys</i> fo. <i>capitata</i> Hust.					
<i>Mastogloia smithii</i> Thwaites ex W. Sm.					
<i>M. smithii</i> var. <i>lacustris</i> Grun.					
<i>Melosira granulata</i> (Ehr.) Ralfs.			1.5		
<i>M. granulata</i> var. <i>angustissima</i> Mull.	0.6	4.1	t	0.6	2.4
<i>M. varians</i> Ag.			t		t
<i>Navicula anglica</i> Ralfs.					
<i>N. anglica</i> var. <i>subsalsa</i> (Grun.) Cl.					
<i>N. capitata</i> Ehr.		t	t		
<i>N. capitata</i> var. <i>hungarica</i> (Grun.) Ross					
<i>N. cincta</i> (Ehr.) Ralfs.					2.9
<i>N. cincta</i> var. <i>rostrata</i> Reim.		t			1.6
<i>N. circumtexta</i> Meist. ex Hust.					
<i>N. cryptocephala</i> Kutz.		t	0.6		2.9
<i>N. cryptocephala</i> var. <i>veneta</i> (Kutz.) Rabh.			0.6		11.2
<i>N. cuspidata</i> (Kutz.) Kutz.					t
<i>N. decussis</i> Østr.					t
<i>N. elmorei</i> Patr.					
<i>N. exigua</i> var. <i>capitata</i> Patr.					
<i>N. hambergii</i> Hust.					
<i>N. heufleri</i> Grun.					0.3
<i>N. heufleri</i> var. <i>leptoccephala</i> (Breb. & Grun.) Patr.					
<i>N. lanceolata</i> (Ag.) Kutz.					
<i>N. minima</i> Grun.					
<i>N. minuscula</i> Grun.			0.3		t
<i>N. mournei</i> Patr.					t
<i>N. notha</i> Wallace					
<i>N. pelliculosa</i> (Breb. ex Kutz.) Hilse					
<i>N. peregrina</i> (Ehr.) Kutz.					
<i>N. protracta</i> Grun.					
<i>N. pupula</i> Kutz.					
<i>N. pupula</i> var. <i>capitata</i> Skv. & Meyer					
<i>N. pygmaea</i> Kutz.					
<i>N. radiosa</i> var. <i>parva</i> Wallace					

## APPENDIX C. Continued

	0227A	0227B	0227C	0227D	0218A
<i>Navicula radiosa</i> var. <i>tenella</i> (Breb. & Kutz.) Grun.					
<i>N. rhynchocephala</i> Kutz.		0.3			0.3
<i>N. rhynchocephala</i> var. <i>germanii</i> (Wallace) Patr. comb. nov.					
<i>N. secreta</i> var. <i>apiculata</i> Patr.	t	0.3			t
<i>N. symmetrica</i> Patr.					
<i>N. tenelloides</i> Hust.				0.3	t
<i>N. tripunctata</i> (O. F. Mull.) Bory		0.9			0.3
<i>N. viridula</i> (Kutz.) Kutz.					
<i>N. viridula</i> var. <i>avenacea</i> (Breb. & Grun.) V.H.		0.9			
<i>N. viridula</i> var. <i>rostellata</i> (Kutz.) Cl.					
<i>N. sp.</i>					t
<i>Neidium dubium</i> (Ehr.) Cl.					
<i>N. iridis</i> var. <i>ampliatum</i> (Ehr.) Cl.					
<i>N. sp.</i>		0.3			
<i>Nitzschia acicularis</i> (Kutz.) W. Sm.	t	0.3			0.3
<i>N. acuminata</i> (W. Sm.) Grun.					
<i>N. amphibia</i> Grun.					0.8
<i>N. angustata</i> (W. Sm.) Grun.					0.3
<i>N. angustata</i> var. <i>acuta</i> Grun.					0.8
<i>N. apiculata</i> (Greg.) Grun.					
<i>N. bulnheimiana</i> (Rabh.) H. L. Sm.					
<i>N. capitellata</i> Hust.					
<i>N. clausii</i> Hantz.					
<i>N. communis</i> Rabh.					
<i>N. denticula</i> Grun.					
<i>N. dissipata</i> (Kutz.) Grun.	t	1.4		0.3	2.9
<i>N. epiphytica</i> O. Mull.					0.5
<i>N. filiformis</i> (W. Sm.) Hust.					
<i>N. fonticola</i> Grun.					
<i>N. frustulum</i> Kutz.					3.2
<i>N. frustulum</i> var. <i>subsalina</i> Hust.		0.3			1.6
<i>N. gracilis</i> Hantz.	t	t			t
<i>N. holsatica</i> Hust.				t	
<i>N. hungarica</i> Grun.					
<i>N. kutzingiana</i> Hilse					
<i>N. linearis</i> (Ag. ex W. Sm.) W. Sm.					1.1

## APPENDIX C. Continued

	<u>0227A</u>	<u>0227B</u>	<u>0227C</u>	<u>0227D</u>	<u>0218A</u>
<i>Nitzschia longissima</i> var. <i>reversa</i> Grun.					
<i>N. microcephala</i> Grun.					
<i>N. palea</i> (Kutz.) W. Sm.	1.0	0.6		0.3	10.6
<i>N. paleacea</i> Grun.					0.5
<i>N. recta</i> Hantz.	t				
<i>N. romana</i> Grun.					0.5
<i>N. sigma</i> (Kutz.) W. Sm.					
<i>N. sigmoidea</i> (Ehr.) W. Sm.					
<i>N. sublinearis</i> Hust.					0.3
<i>N. tryblionella</i> Hantz.					
<i>N. tryblionella</i> var. <i>debilis</i> (Arnott) A. Mayer					
<i>N. tryblionella</i> var. <i>levidensis</i> (W. Sm.) Grun.					
<i>N. tryblionella</i> var. <i>victoriae</i> Grun.					
<i>N. valdestriata</i> Aleem & Hust.					0.3
<i>N. vermicularis</i> (Kutz.) Hant.					t
<i>N. sp.</i>					0.8
<i>Pinnularia borealis</i> Ehr.					
<i>P. kneuckerii</i> Hust.					
<i>P. sp.</i>		t			
<i>Pleurosigma delicatulum</i> W. Sm.					
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.					
<i>Rhopalodia gibba</i> (Ehr.) O. Mull.					0.5
<i>R. gibba</i> var. <i>ventricosa</i> (Kutz.) H. & M. Perag.					
<i>R. musculus</i> (Kutz.) O. Mull.					
<i>Stauroneis</i> sp. Ehr.					
<i>Stephanodiscus astraea</i> (Ehr.) Grun.	4.8	35.6	t	31.3	0.3
<i>S. minutus</i> Cl. & Moll.	93.0	38.6	t	1.9	0.3
<i>S. niagarae</i> Ehr.					
<i>Surirella angustata</i> Kutz.					
<i>S. iowensis</i> Lowe					
<i>S. ovalis</i> Breb.					
<i>S. ovata</i> Kutz.		t			
<i>S. tenera</i> Greg.					
<i>Synedra acus</i> Kutz.					t
<i>S. cyclopus</i> Brutschy			t		

APPENDIX C. Concluded

0227A 0227B 0227C 0227D 0218A

*Synedra delicatissima* W. Sm.

t

*S. fasciculata* var. *truncata* (Grev.) Patr.

*S. goulardi* Breb.

*S. mazamaensis* Sov.

*S. radians* Kutz.

*S. rumpens* Kutz.

*S. ulna* (Nitz. ) Ehr.

t

*S. ulna* var. *contracta* Østr.

0.3

*S. ulna* var. *spathulifera* (Grun.) V.H.

*S. sp.*

APPENDIX D. Percent relative abundance of diatom taxa from the Tongue River,  
September 1977.

	<u>0362A</u>	<u>0363A</u>	<u>0364A</u>	<u>0116C</u>
<i>Achnanthes affinis</i> Grun.			1.2	
<i>A. clevei</i> Grun.			2.8	
<i>A. clevei</i> var. <i>rostrata</i> Hust.				
<i>A. lanceolata</i> (Breb.) Grun.	t	0.3	t	t
<i>A. lanceolata</i> var. <i>dubia</i> Grun.	1.2		6.6	0.6
<i>A. linearis</i> (W. Sm.) Grun.				
<i>A. minutissima</i> Kutz.	0.3	2.0	9.4	7.0
<i>Amphipleura pellucida</i> Kutz.				0.6
<i>Amphora ovalis</i> var. <i>affinis</i> (Kutz.) V.H. ex DeT.				0.3
<i>A. ovalis</i> var. <i>pediculus</i> (Kutz.) V.H.			t	
<i>A. perpusilla</i> (Grun.) Grun.	0.6	0.9	9.4	0.6
<i>A. veneta</i> (Kutz.) Hust.				
<i>Anomoeoneis vitrea</i> (Grun.) Ross comb. nov.				
<i>Asterionella formosa</i> Hass.				t
<i>Bacillaria paradoxa</i> Gmel.				
<i>Caloneis amphisbaena</i> (Bory) Cl.				
<i>C. bacillum</i> (Grun.) Cl.				
<i>C. hyalina</i> Hust.				
<i>C. lewisii</i> Patr.				
<i>C. limosa</i> (Kutz.) Patr. comb. nov.				
<i>C. ventricosa</i> var. <i>truncatula</i> (Grun.) Meist.				
<i>C. sp.</i>				
<i>Cocconeis pediculus</i> Ehr.	1.5	0.6	25.3	20.4
<i>C. placentula</i> Ehr.	4.6	1.4	6.2	2.2
<i>C. placentula</i> var. <i>euglypta</i> (Ehr.) Cl.				
<i>Cyclotella meneghiniana</i> Kutz.	0.9	0.6		
<i>C. sp.</i>				
<i>Cymatopleura elliptica</i> var. <i>nobilis</i> (Hant.) Hust.	0.3			
<i>C. solea</i> (Breb. & Godey) W. Sm.	t		0.3	
<i>Cymbella affinis</i> Kutz.	0.3	t	0.9	t
<i>C. cistula</i> (Ehr.) Kirchn.				
<i>C. cymbiformis</i> Ag.				
<i>C. mexicana</i> (Ehr.) Cleve				
<i>C. microcephala</i> Grun.				
<i>C. minuta</i> Hilse ex Rabh.			t	t
<i>C. muelleri</i> Hust.				

APPENDIX D. Continued

	0362A	0363A	0364A	0116C
<i>Cymbella prostrata</i> (Berkeley) Cl.			t	
<i>C. prostrata</i> var. <i>auerswaldii</i> (Rabh.) Reim. comb. nov.	0.3		t	t
<i>C. pusilla</i> Grun.				
<i>C. sinuata</i> Greg.	0.3	0.3	1.6	0.8
<i>C. tumida</i> (Breb.) V.H.	t	0.3	t	
<i>Denticula</i> sp.				
<i>Diatoma elongatum</i> var. <i>minor</i> Grun.				
<i>D. tenue</i> var. <i>elongatum</i> Lyngb.				
<i>D. vulgare</i> Bory	4.9	7.8	0.6	t
<i>Diploneis puella</i> (Schum.) Cl.				
<i>Entomoneis alata</i> (Ehr.) Ehr.				
<i>E. paludosa</i> (W. Sm.) Reim. comb. nov.				
<i>Epithemia adnata</i> (Kutz.) Breb.			0.9	1.4
<i>E. adnata</i> var. <i>proboscidea</i> (Kutz.) Patr. comb. nov.			t	t
<i>E. adnata</i> var. <i>saxonica</i> (Kutz.) Patr. comb. nov.			t	
<i>E. sorex</i> Kutz.	28.0	15.9	1.2	16.8
<i>E. sp.</i>				
<i>Fragilaria brevistriata</i> var. <i>inflata</i> (Pant.) Hust.				
<i>F. construens</i> var. <i>venter</i> (Ehr.) Grun.	0.6		0.6	
<i>F. crotonensis</i> Kitton.				
<i>F. vaucheriae</i> (Kutz.) Peters	0.3	0.9	1.2	8.1
<i>F. virescens</i> var. <i>capitata</i> Østr.				
<i>Frustulia weinholdii</i> Hust.				
<i>Gomphoneis herculeana</i> var. <i>robusta</i> (Grun.) Cl.				
<i>Gomphonema acuminatum</i> Ehr.				
<i>G. affine</i> Kutz.				
<i>G. angustatum</i> (Kutz.) Rabh.				
<i>G. angustatum</i> var. <i>sarcophagus</i> (Greg.) Grun.				
<i>G. dichotomum</i> Kutz.				
<i>G. intricatum</i> Kutz.				
<i>G. olivaceum</i> (Lyngb.) Kutz.		0.3	0.9	0.3
<i>G. olivaceum</i> var. <i>calcareo</i> (Cl.) Cl.				
<i>G. parvulum</i> Kutz.			t	
<i>G. subclavatum</i> (Grun.) Grun.			t	1.6
<i>G. sp.</i>	0.3		t	0.9



## APPENDIX D. Continued

	<u>0362A</u>	<u>0363A</u>	<u>0364A</u>	<u>0116C</u>
<i>Gyrosigma spencerii</i> (Quek.) Griff. & Henfr.				0.3
<i>Hantzschia amphioxys</i> (Ehr.) Grun.				t
<i>H. amphioxys</i> fo. <i>capitata</i> Hust.				
<i>Mastogloia smithii</i> Thwaites ex W. Sm.				
<i>M. smithii</i> var. <i>lacustris</i> Grun.				
<i>Melosira granulata</i> (Ehr.) Ralfs.				
<i>M. granulata</i> var. <i>angustissima</i> Mull.			0.3	
<i>M. varians</i> Ag.	2.5	1.2	0.6	
<i>Navicula anglica</i> Ralfs.		t		
<i>N. anglica</i> var. <i>subsalsia</i> (Grun.) Cl.			t	
<i>N. capitata</i> Ehr.				
<i>N. capitata</i> var. <i>hungarica</i> (Grun.) Ross				
<i>N. cincta</i> (Ehr.) Ralfs.			0.3	
<i>N. cincta</i> var. <i>rostrata</i> Reim.		0.6	t	
<i>N. circumtexta</i> Meist. ex Hust.				
<i>N. cryptocephala</i> Kutz.	4.9	10.7	3.4	0.8
<i>N. cryptocephala</i> var. <i>veneta</i> (Kutz.) Rabh.	4.3	3.5	4.1	5.3
<i>N. cuspidata</i> (Kutz.) Kutz.	t	0.3		
<i>N. decussis</i> Østr.				
<i>N. elmorei</i> Patr.			t	
<i>N. exigua</i> var. <i>capitata</i> Patr.	0.6			
<i>N. hambergii</i> Hust.				
<i>N. heuffleri</i> Grun.				0.3
<i>N. heuffleri</i> var. <i>leptocephala</i> (Breb. & Grun.) Patr.				
<i>N. lanceolata</i> (Ag.) Kutz.				
<i>N. minima</i> Grun.				0.3
<i>N. minuscula</i> Grun.				
<i>N. mournei</i> Patr.				
<i>N. notha</i> Wallace				
<i>N. pelliculosa</i> (Breb. ex Kutz.) Hilse				
<i>N. peregrina</i> (Ehr.) Kutz.				
<i>N. protracta</i> Grun.				11.2
<i>N. pupula</i> Kutz.	0.3			
<i>N. pupula</i> var. <i>capitata</i> Skv. & Meyer				
<i>N. pygmaea</i> Kutz.			t	
<i>N. radiosa</i> var. <i>parva</i> Wallace	t	0.6	t	

## APPENDIX D. Continued

	0362A	0363A	0364A	0116C
<i>Navicula radiosa</i> var. <i>tenella</i> (Breb. & Kutz.) Grun.				
<i>N. rhynchocephala</i> Kutz.	t	1.2		
<i>N. rhynchocephala</i> var. <i>germanii</i> (Wallace) Patr. comb. nov.	0.3			
<i>N. secreta</i> var. <i>apiculata</i> Patr.	0.6	1.2	t	0.6
<i>N. symmetrica</i> Patr.	0.3	5.8		0.3
<i>N. tenelloides</i> Hust.				
<i>N. tripunctata</i> (O. F. Mull.) Bory	4.3	3.5	1.6	0.8
<i>N. viridula</i> (Kutz.) Kutz.				
<i>N. viridula</i> var. <i>avenacea</i> (Breb. & Grun.) V.H.		5.2		
<i>N. viridula</i> var. <i>rostellata</i> (Kutz.) Cl.		0.6		
<i>N. sp.</i>			0.6	t
<i>Neidium dubium</i> (Ehr.) Cl.			t	
<i>N. iridis</i> var. <i>ampliatum</i> (Ehr.) Cl.				
<i>N. sp.</i>				
<i>Nitzschia acicularis</i> (Kutz.) W. Sm.	0.3	0.9		0.3
<i>N. acuminata</i> (W. Sm.) Grun.				
<i>N. amphibia</i> Grun.				
<i>N. angustata</i> (W. Sm.) Grun.			t	
<i>N. angustata</i> var. <i>acuta</i> Grun.				
<i>N. apiculata</i> (Greg.) Grun...	0.3	0.6	0.3	
<i>N. bulnheimiana</i> (Rabh.) H. L. Sm.				
<i>N. capitellata</i> Hust.				
<i>N. clausii</i> Hantz.				
<i>N. communis</i> Rabh.				
<i>N. denticula</i> Grun.				
<i>N. dissipata</i> (Kutz.) Grun.	6.8	4.1	7.2	3.6
<i>N. epiphytica</i> O. Mull.				0.6
<i>N. filiformis</i> (W. Sm.) Hust.	0.9	0.3		
<i>N. fonticola</i> Grun.				
<i>N. frustulum</i> Kutz.		2.0	0.6	0.6
<i>N. frustulum</i> var. <i>subsalina</i> Hust.	1.2	12.5	3.4	17.9
<i>N. gracilis</i> Hantz.				
<i>N. holsatica</i> Hust.				
<i>N. hungarica</i> Grun.	t			t
<i>N. kutzingiana</i> Hilse		2.0		0.2
<i>N. linearis</i> (Ag. ex W. Sm.) W. Sm.	1.5	0.3	t	

## APPENDIX D. Continued

	0362A	0363A	0364A	0116C
<i>Nitzschia longissima</i> var. <i>reversa</i> Grun.		0.3		
<i>N. microcephala</i> Grun.				
<i>N. palea</i> (Kutz.) W. Sm.	8.3	3.5	1.2	0.6
<i>N. paleacea</i> Grun.				
<i>N. recta</i> Hantz.				
<i>N. romana</i> Grun.	0.3		t	
<i>N. sigma</i> (Kutz.) W. Sm.				
<i>N. sigmoidea</i> (Ehr.) W. Sm.	t	t		
<i>N. sublinearis</i> Hust.				
<i>N. tryblionella</i> Hantz.		0.3		
<i>N. tryblionella</i> var. <i>debilis</i> (Arnott) A. Mayer				
<i>N. tryblionella</i> var. <i>levidensis</i> (W. Sm.) Grun.				
<i>N. tryblionella</i> var. <i>victoriae</i> Grun.				
<i>N. valdestriata</i> Aleem & Hust.				
<i>N. vermicularis</i> (Kutz.) Hant.				
<i>N. sp.</i>	0.3	1.4		1.4
<i>Pinnularia borealis</i> Ehr.		0.3		
<i>P. kneuckerii</i> Hust.				
<i>P. sp.</i>				
<i>Pleurosigma delicatulum</i> W. Sm.	t	t		
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.	4.0	0.9	3.8	1.4
<i>Rhopalodia gibba</i> (Ehr.) O. Mull.			0.3	t
<i>R. gibba</i> var. <i>ventricosa</i> (Kutz.) H. & M. Perag.	0.6	1.2	t	
<i>R. musculus</i> (Kutz.) O. Mull.				
<i>Stauroneis</i> sp. Ehr.				
<i>Stephanodiscus astraea</i> (Ehr.) Grun.			t	
<i>S. minutus</i> Cl. & Moll.	4.3	2.6	0.3	2.0
<i>S. niagarae</i> Ehr.				
<i>Surirella angustata</i> Kutz.				
<i>S. iowensis</i> Lowe				
<i>S. ovalis</i> Breb.				
<i>S. ovata</i> Kutz.		0.3		
<i>S. tenera</i> Greg.				
<i>Synedra acus</i> Kutz.	1.2	t	t	
<i>S. cyclopus</i> Brutschy				

APPENDIX D. Concluded

0362A 0363A 0364A 0116C

*Synedra delicatissima* W. Sm.

*S. fasciculata* var. *truncata* (Grev.) Patr.

*S. goulardi* Breb.

*S. mazamaensis* Sov.

*S. radians* Kutz.

*S. rumpens* Kutz.

*S. ulna* (Nitz. ) Ehr.

*S. ulna* var. *contracta* Østr.

*S. ulna* var. *spathulifera* (Grun.) V.H.

*S. sp.*

t

7.1

1.2